SOUTHERN ROCKIES
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Fuel Treatments as a Strategy to Mitigate Climate Impacts on Wildfire, Vegetation, and Water on the Kaibab Plateau, AZ

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Restoration Treatments as a Strategy to Mitigate Climate Impacts on Wildfire, Vegetation and Water on the Kaibab Plateau, AZ

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TRIF
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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Linking Forest Modeling to Hydrology on the Kaibab Plateau

http://www.mygrandcanyonpark.com

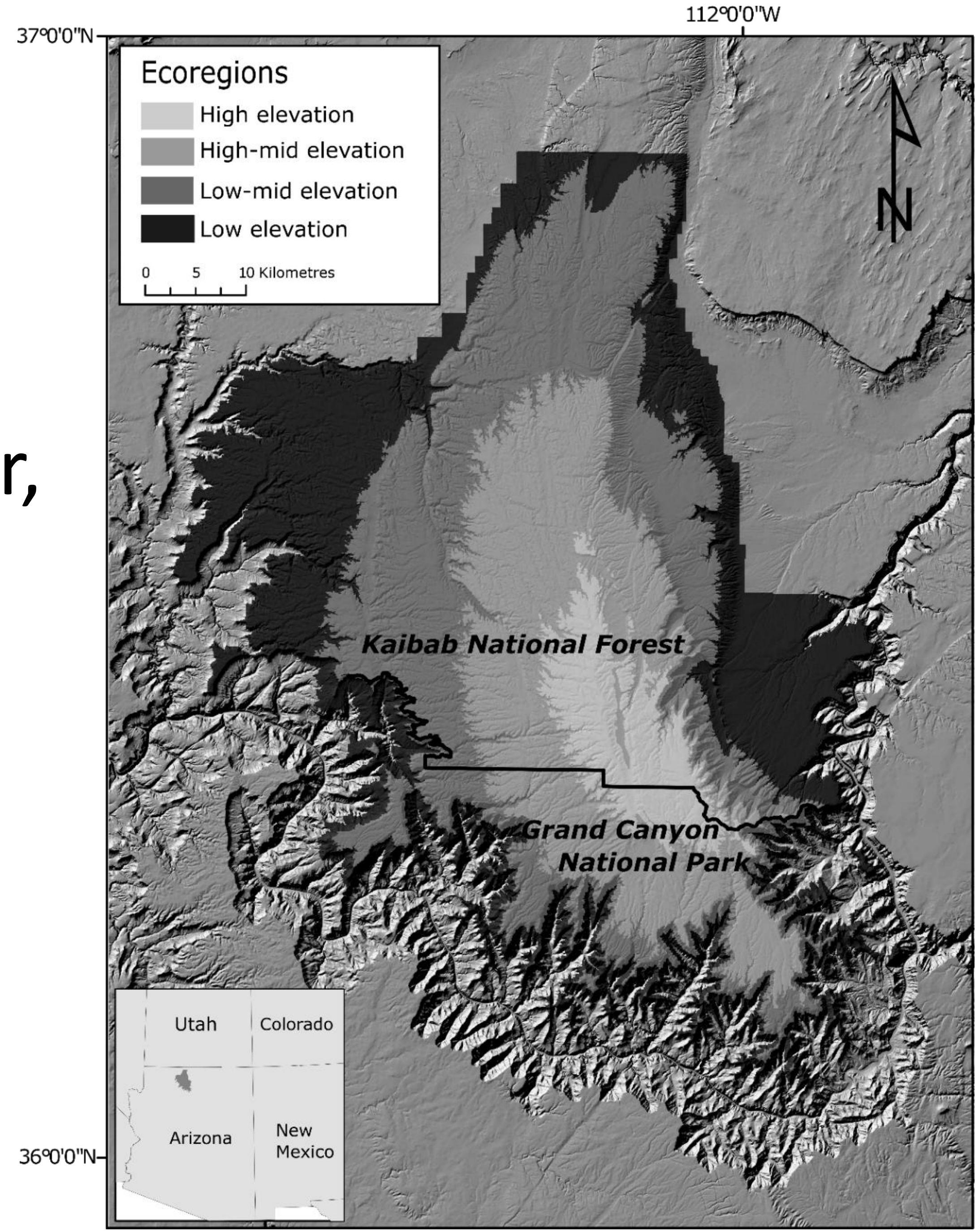
Study Objectives

1. Predict changes in fire regimes and forest vegetation under a range of climate and restoration scenarios
2. Estimate changes in future hydrologic and sediment output due to restoration and forest type change
3. Identify areas of the Kaibab Plateau that are most likely to experience negative hydrologic impacts

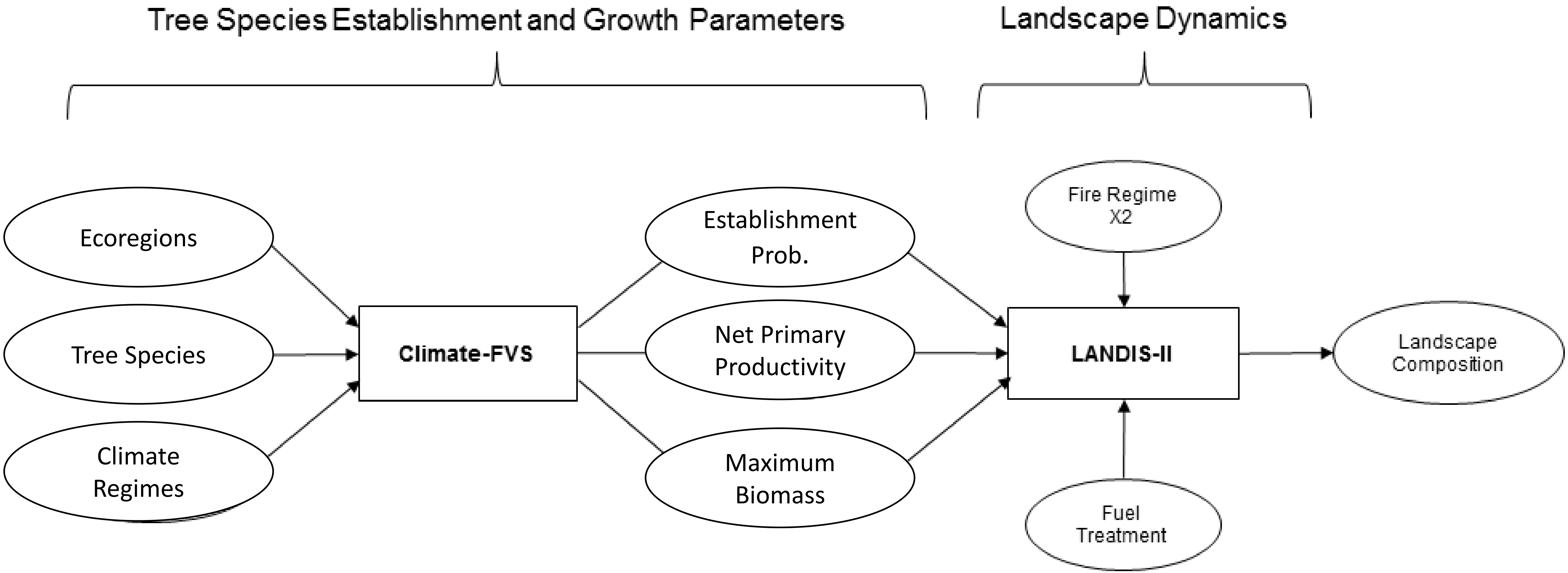
Kaibab Plateau, AZ

- **Area**: 828,000 acres
- **Elevation**: 4,725 to 9,284 ft
- **Forest Types**: pinyon-juniper, ponderosa, mixed conifer, spruce-fir
- **Fire Regimes**: variable frequency and severity

- Dendroecological data



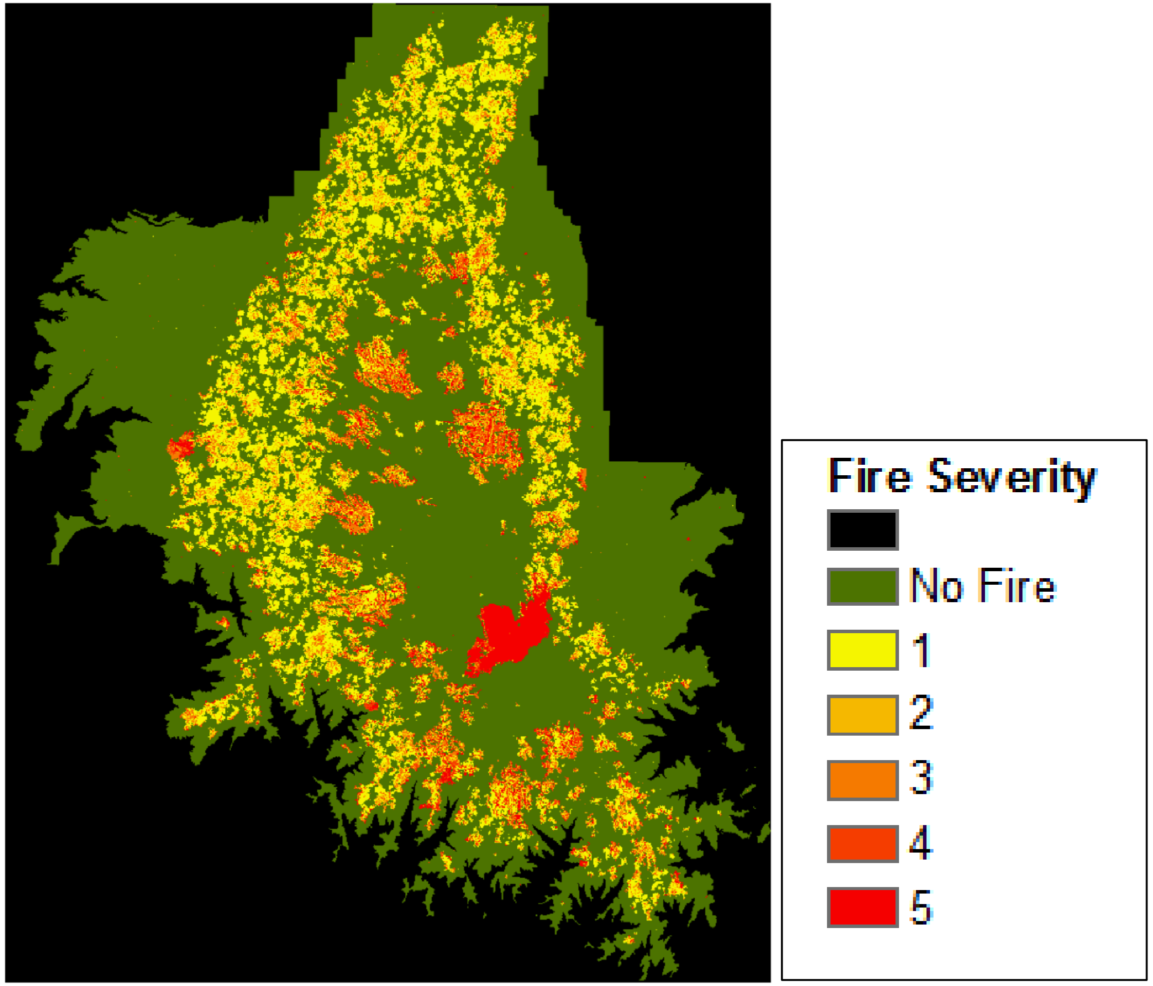
Methods: Forest Modeling Approach



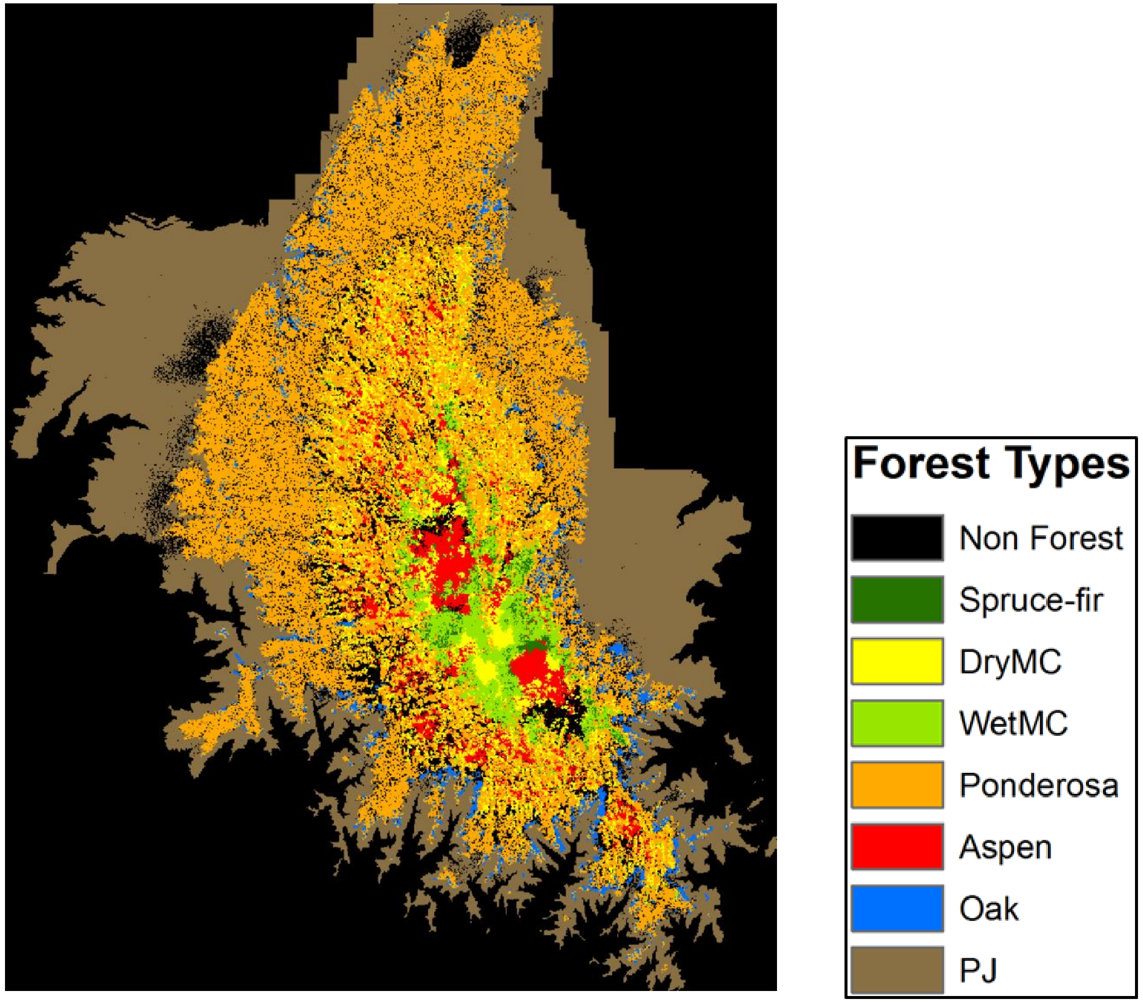
Flatley, W. T., and P. Z. Fulé. 2016. Are historical fire regimes compatible with future climate? Implications for forest restoration. Ecosphere 7:e01471-n/a.

Model Outputs: Historical Fire Regime

Fire Severity



Forest Composition



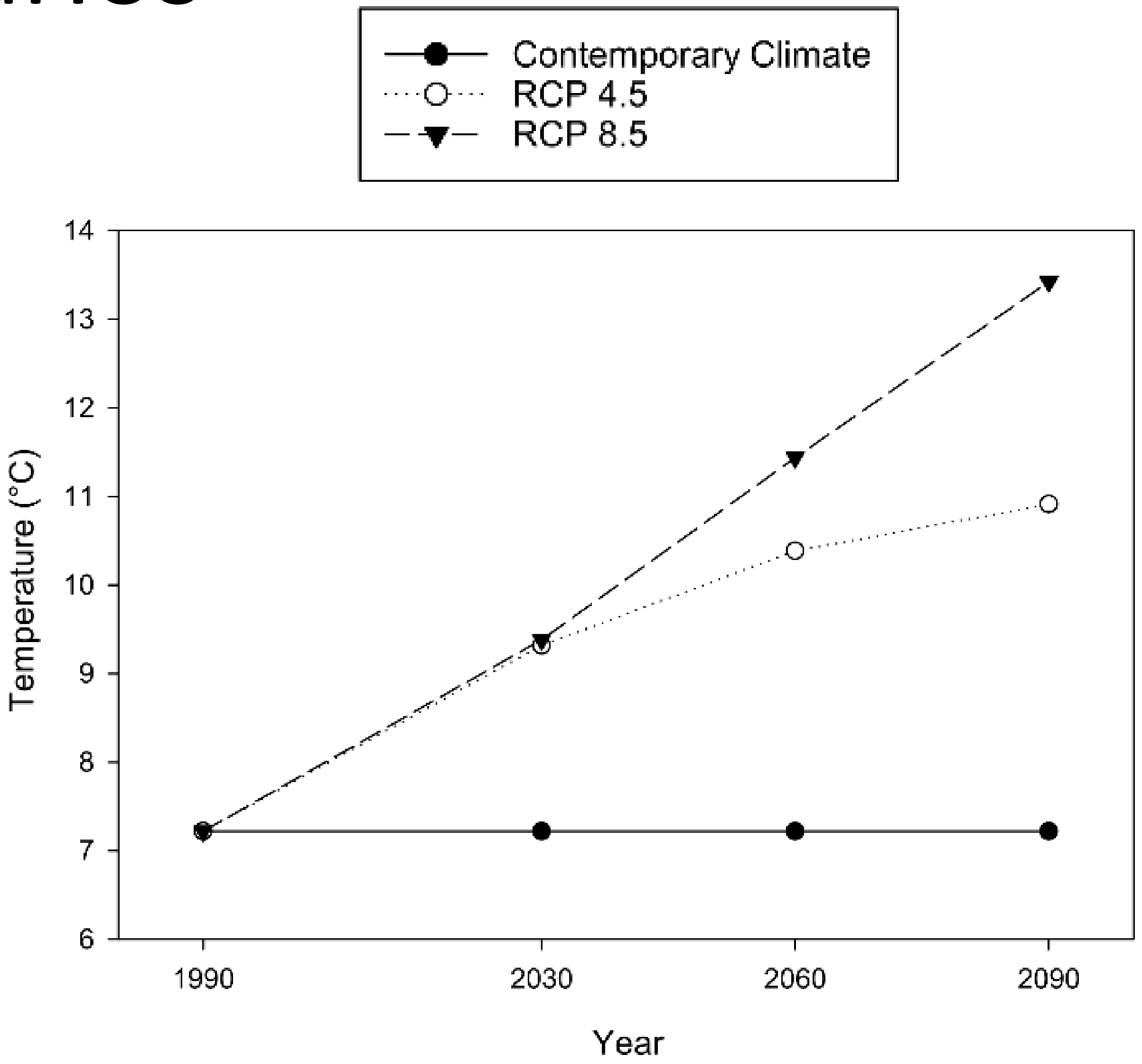
Flatley, W. T., and P. Z. Fulé. 2016. Are historical fire regimes compatible with future climate? Implications for forest restoration. Ecosphere 7:e01471-n/a.

Methods: Climate Scenarios

1. Contemporary Climate

2. Ensemble RCP 4.5
   (5.9°F increase)

3. Ensembel RCP 8.5
   (9.9°F increase)



Methods: Restoration Scenarios

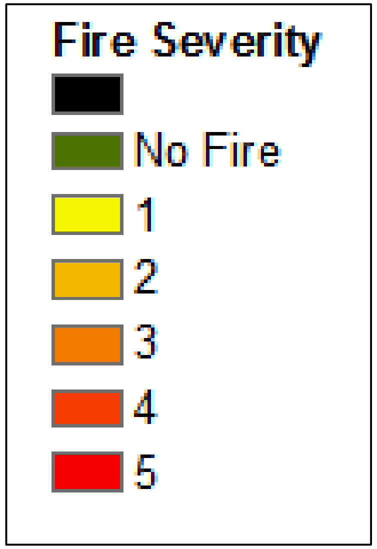
1. **No Restoration**
2. **Low Restoration**: Thinning or prescribed burns on 1.25% of the target area per year (80 year rotation)
3. **High Restoration**: Thinning or prescribed burns on 5% of the target area per year (20 year rotation)

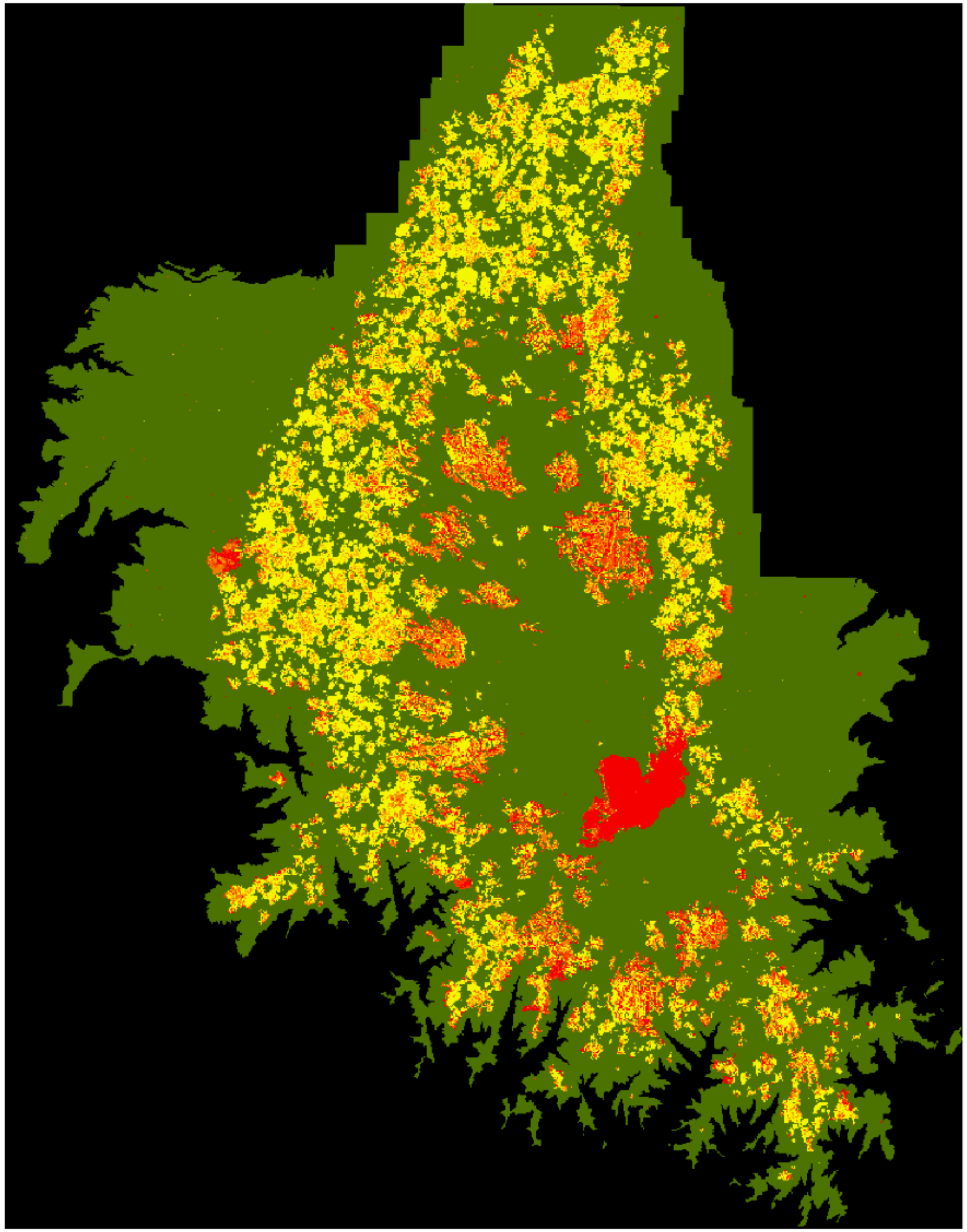
Results: High Severity Area Burned in thousands of acres from 2010-2110

Climate Condition	Restoration Rate		
	No Restoration	Low Restoration	High Restoration
No Change	505.3 (61.5)	356.8 (37.8)	206.1 (47)
RCP 4.5	485.3 (34.3)	343.7 (41.8)	187.8 (40)
RCP 8.5	513.7 (38.1)	356.1 (50.4)	215 (36.1)

High Severity Fire and Climate Change

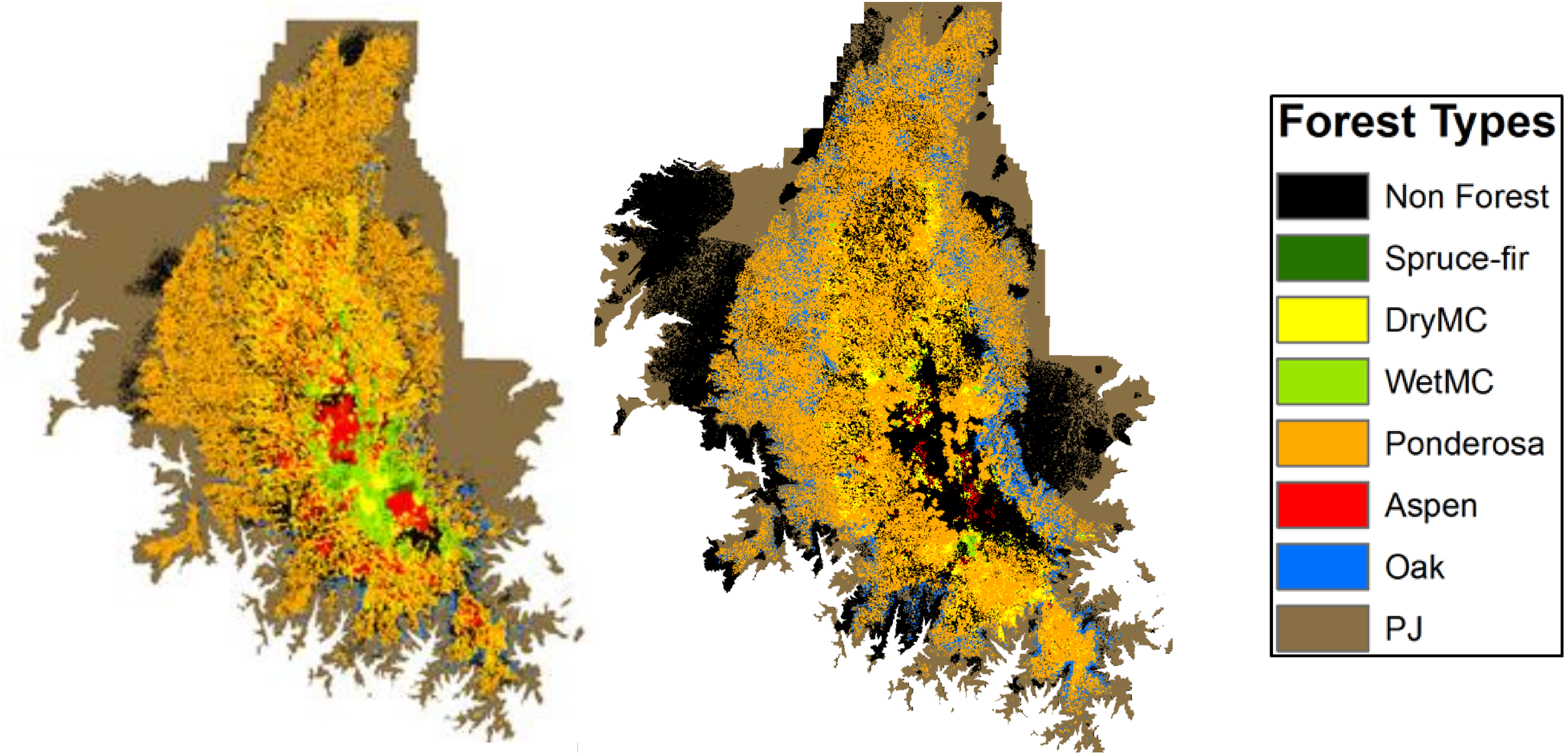
- High severity fire drives forest turnover and resulting compositional change



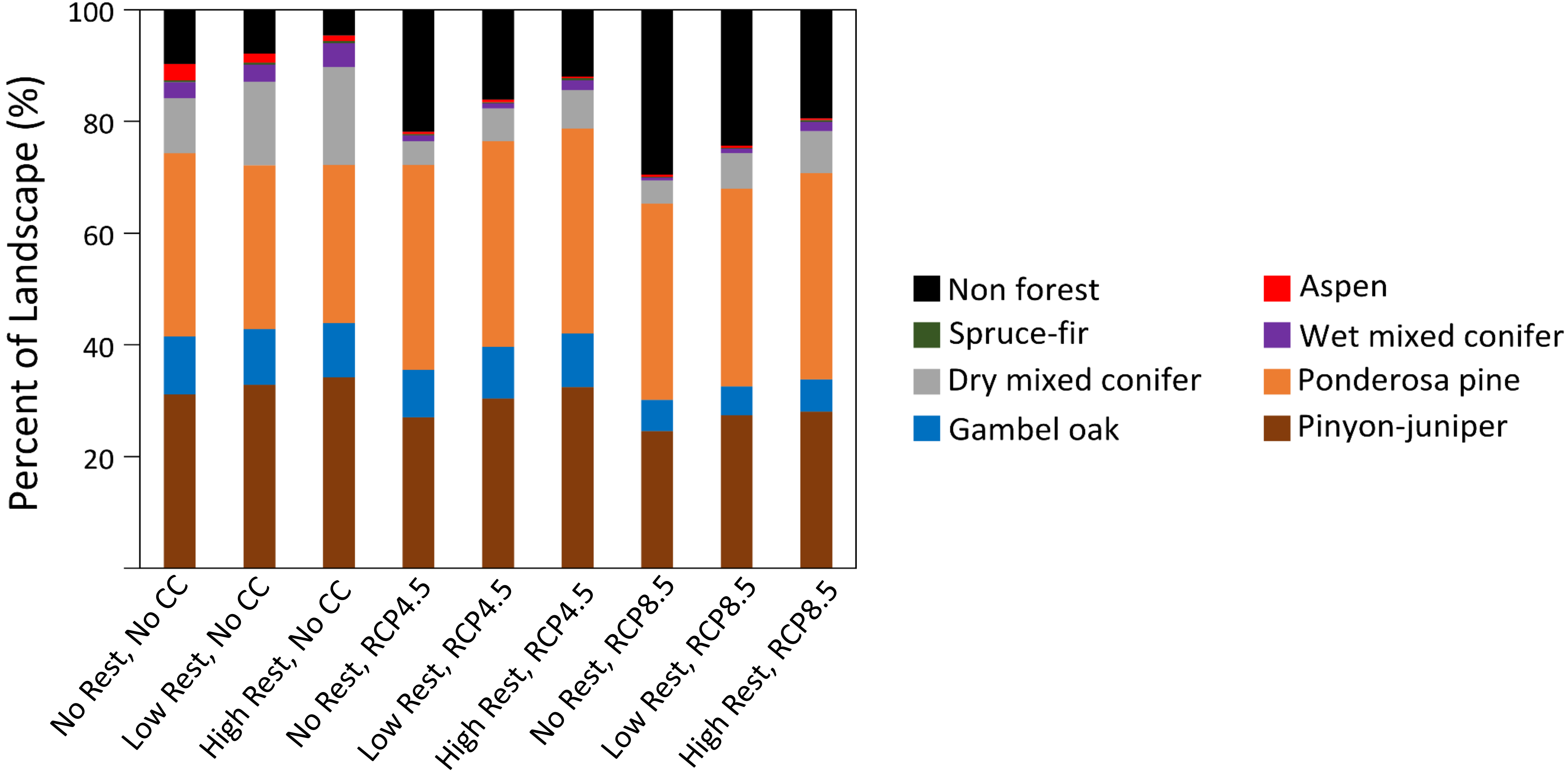


Forest Composition under historical fire regime and climate

Forest Composition in 2110 RCP 8.5 No Restoration



Results: Percent of Landscape in different Forest Types in 2110



Conclusions

- Decline of mesic conifers and aspen
- Shift toward pinyon-juniper and ponderosa pine forest types
- Restoration reduces high severity fire, non-forest area and delays the decline of legacy forests
- Both low and high restoration rates have beneficial outcomes

photo courtesy of Pete Fulé

Questions?

photo courtesy of Pete Fulé

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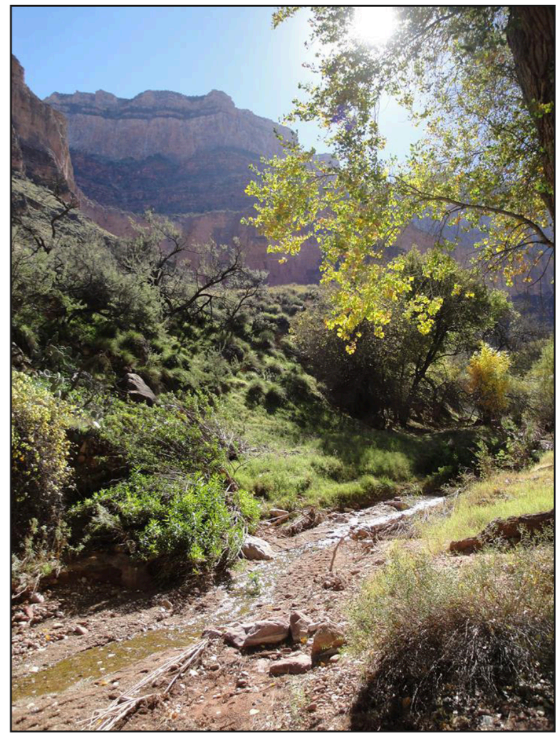
Part II: Hydrologic Modeling



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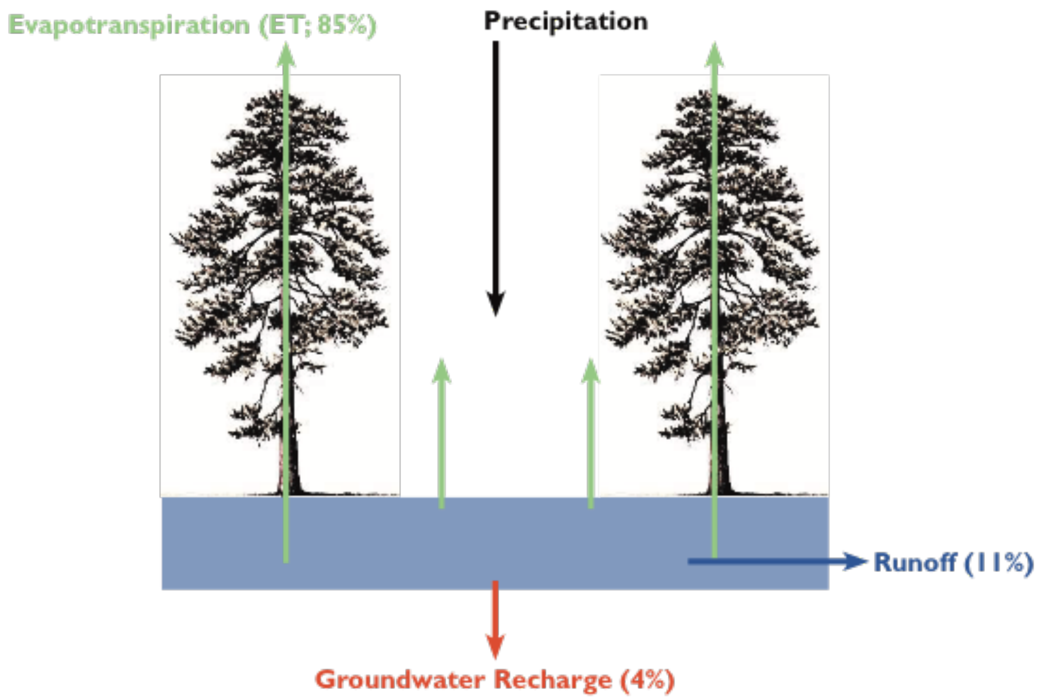
Northern Arizona University

Linking Vegetation to Water



Wyatt et al. (2014)

Linking Vegetation to Water

Oak Savanna

405 m.a.s.l.
513 mm MAP

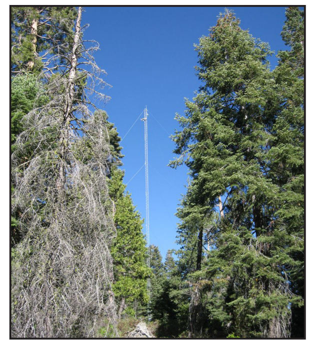
85%

Ponderosa Forest

1160 m.a.s.l.
805 mm MAP

75%

Mixed Conifer Forest



2015 m.a.s.l.
1015 mm MAP

63%

Subalpine Forest

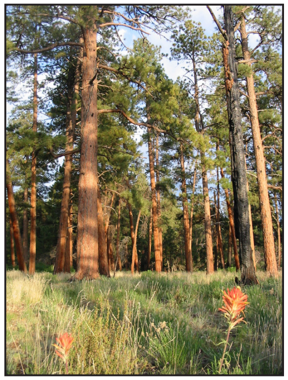
2700 m.a.s.l.
1078 mm MAP

44%

ET as percent of precipitation

Goulden et al. (2012)
Photos: http://criticalzone.org/sierra/

Linking Disturbance to Water

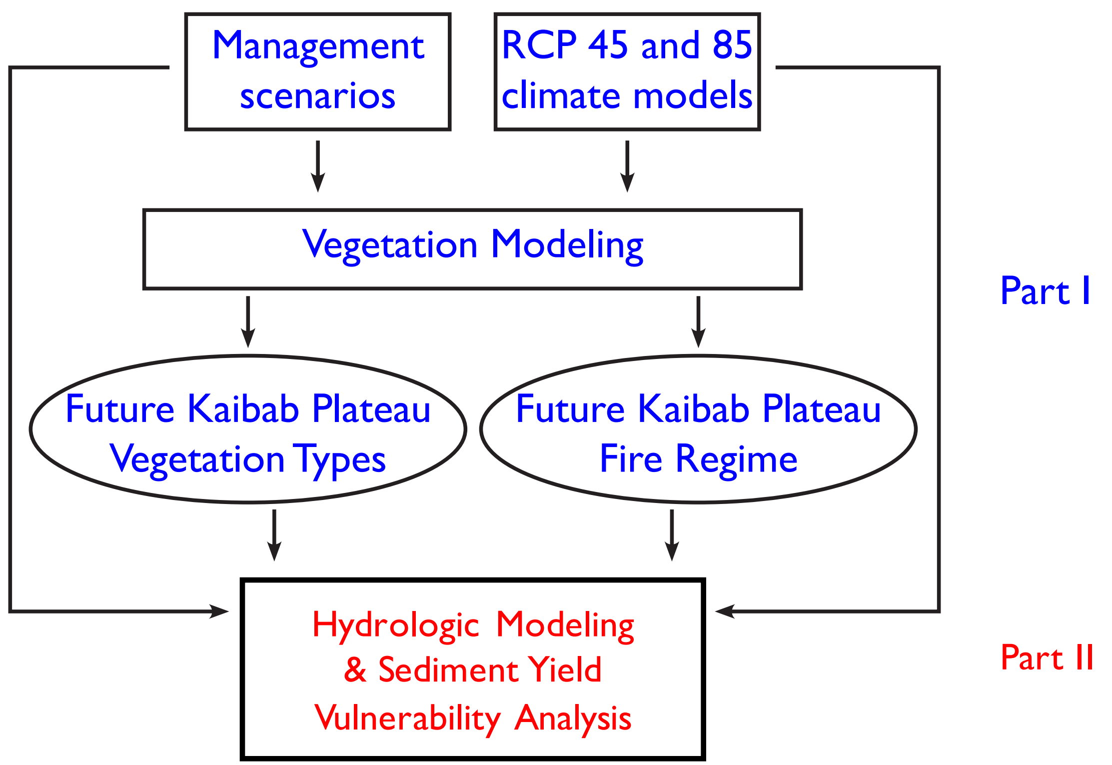


Forest Restoration
1-16% reduction in ET
Little to no increase
in suspended sediment

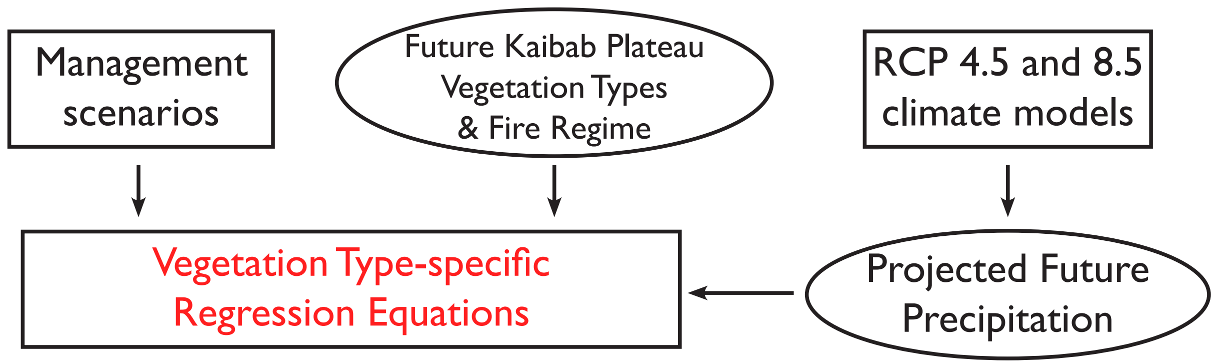
High-Intensity Wildfire
13-29% reduction in ET
Large (>100 x higher) increase
in suspended sediment

How will vegetation type shifts, restoration, and disturbances affect the quantity and quality of runoff from the Kaibab Plateau?

Modeling Approach Overview



Methods: Hydrologic Modeling



Historic Paired Watersheds Across Arizona

Alpine Grassland
Seven Springs

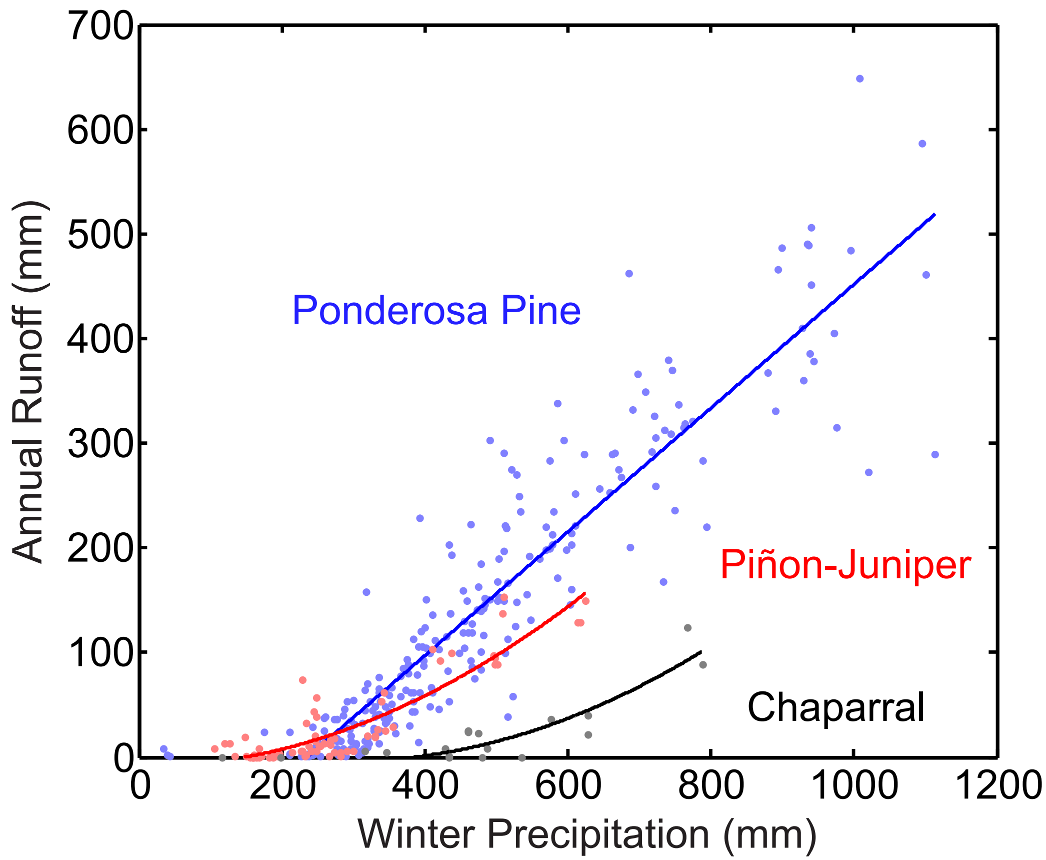
Mixed Conifer
Workman Creek
Willow Creek
Thomas Creek

Ponderosa
Beaver Creek
Castle Creek
Stermer Ridge
Rattle Burn

Piñon-Juniper
Beaver Creek
Corduroy Creek
Mingus Mountain

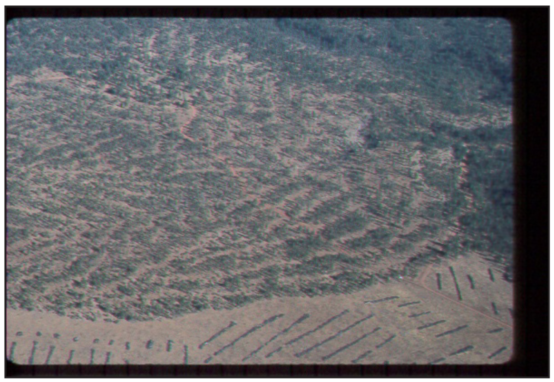
Chaparral
Mingus Mountain
Whitespar
Three Bar

Regression Equations



Historic Paired Watersheds Across Arizona

Strip-cut Thinning Ponderosa
Beaver Creek



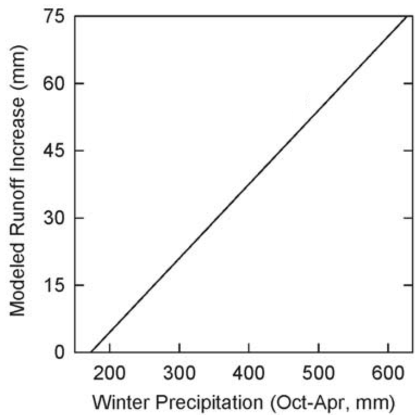
USDA Forest Service Photograph

Cable Removal of Juniper
Beaver Creek

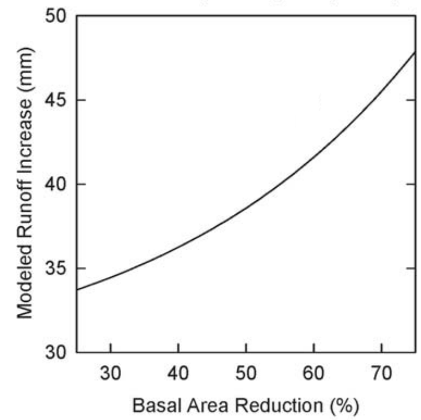
Clary et al. (1974)

Modeling the Effect of Thinning

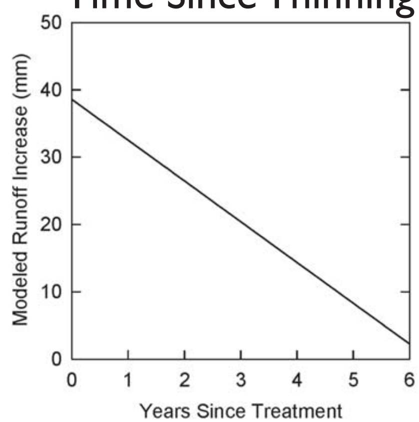
Climate



Thinning Intensity

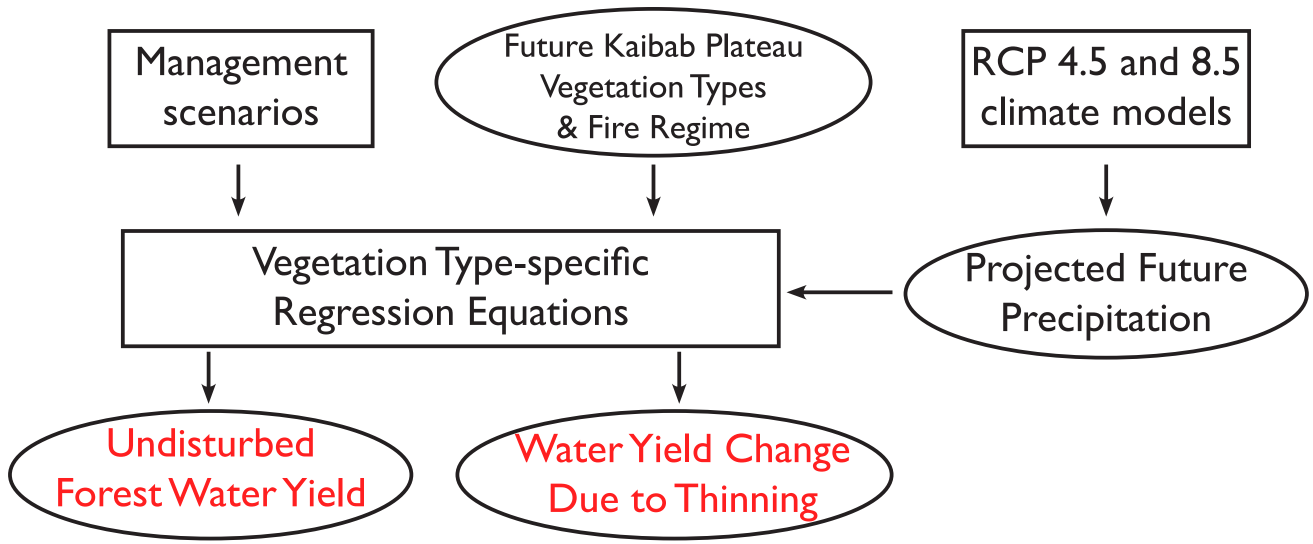


Time Since Thinning

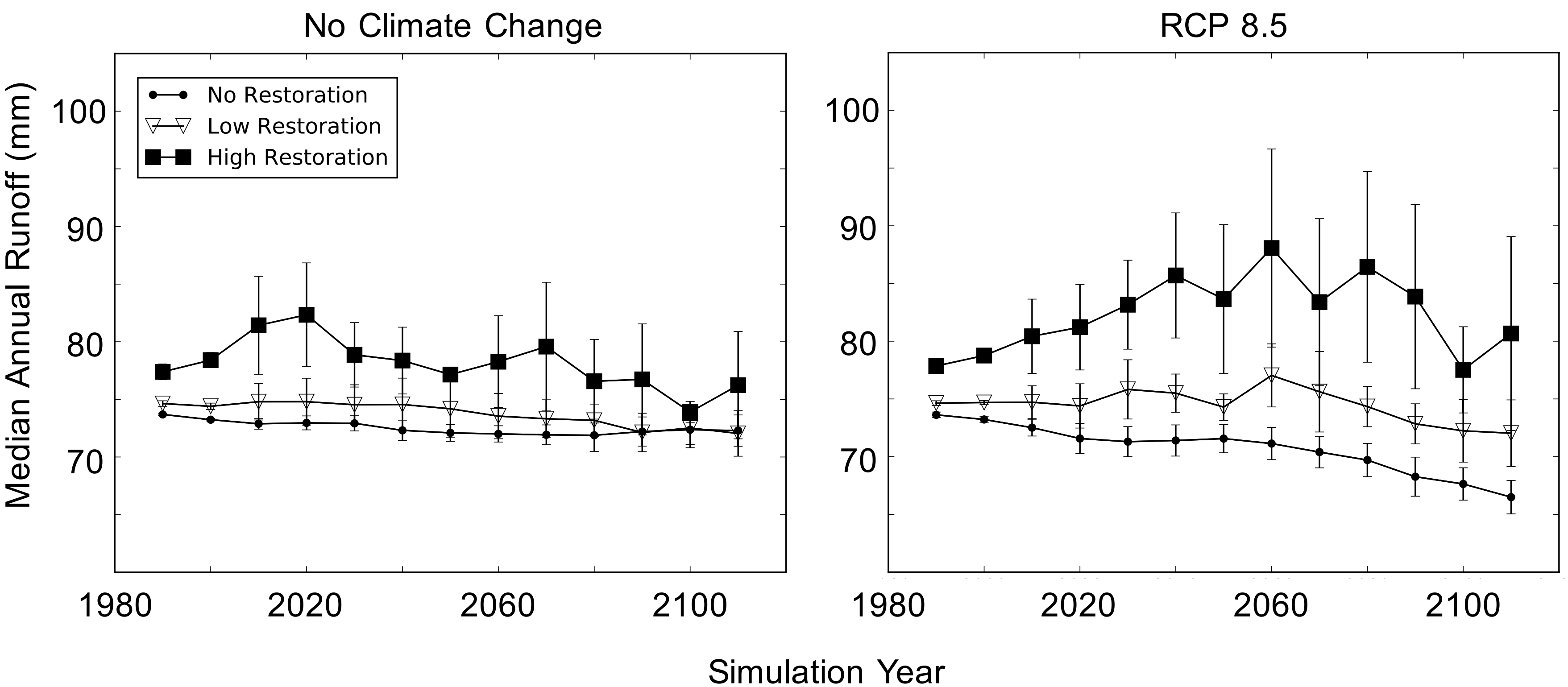


Robles et al. (2014)

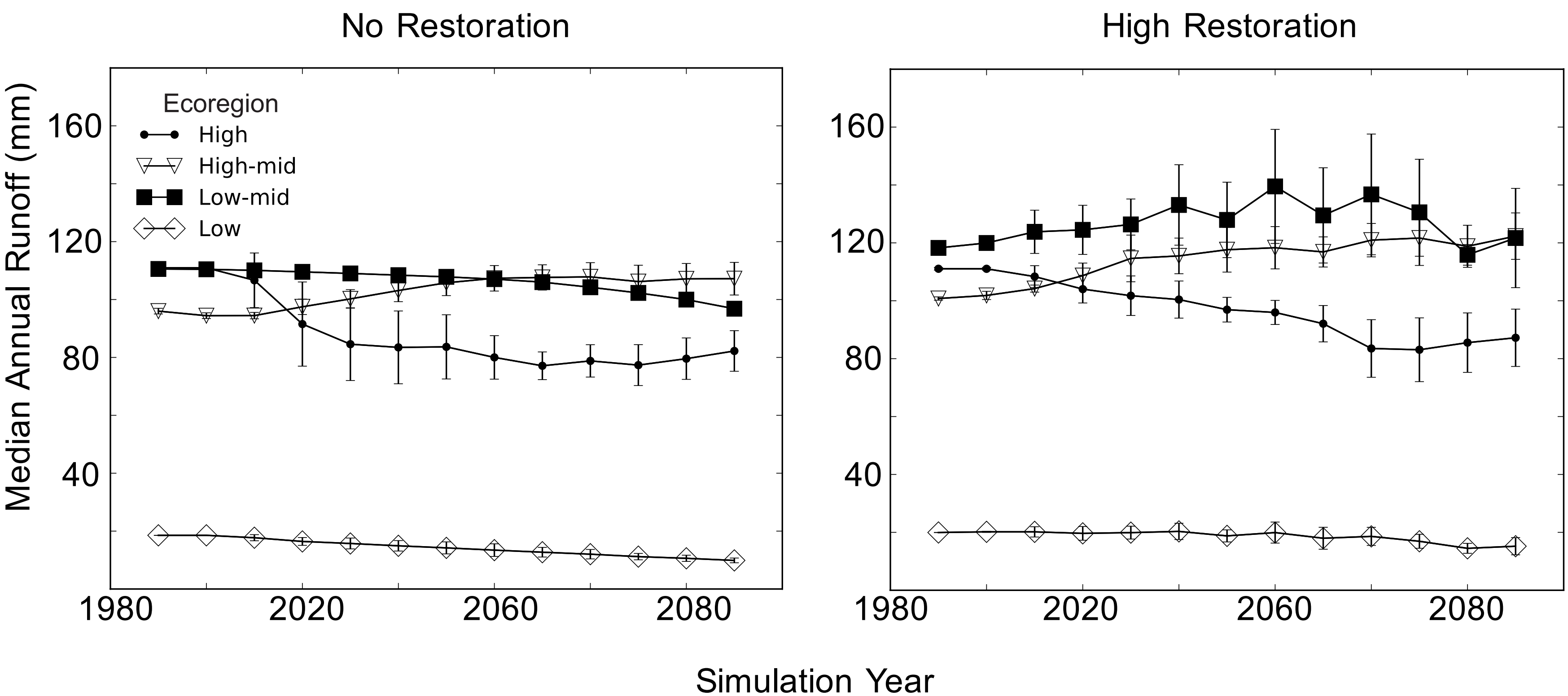
Methods: Hydrologic Modeling



Results: Total Runoff

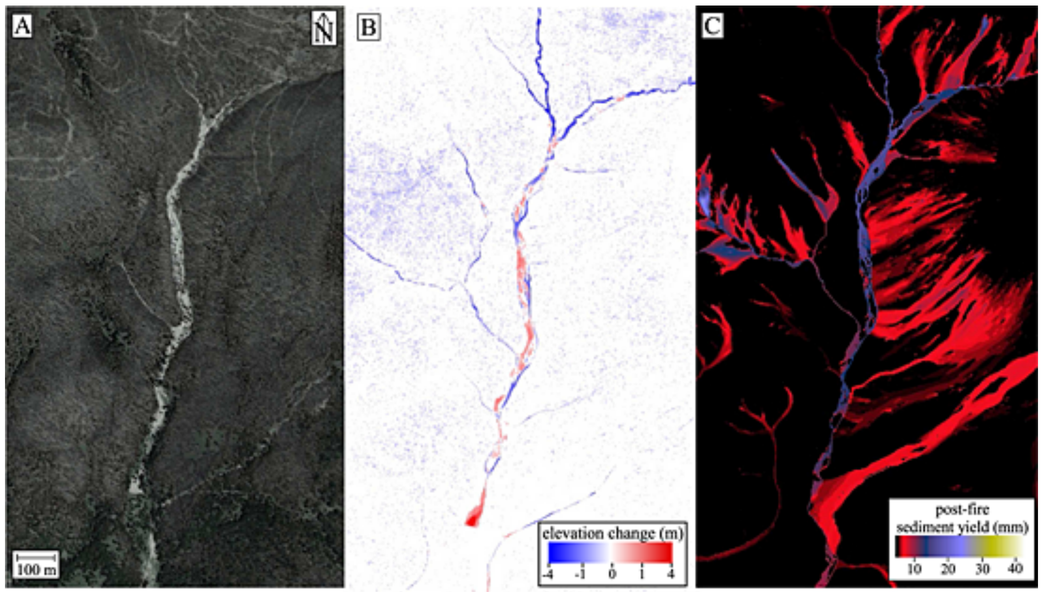


Results: Runoff by Ecoregion



Methods: Sediment Yield Vulnerability

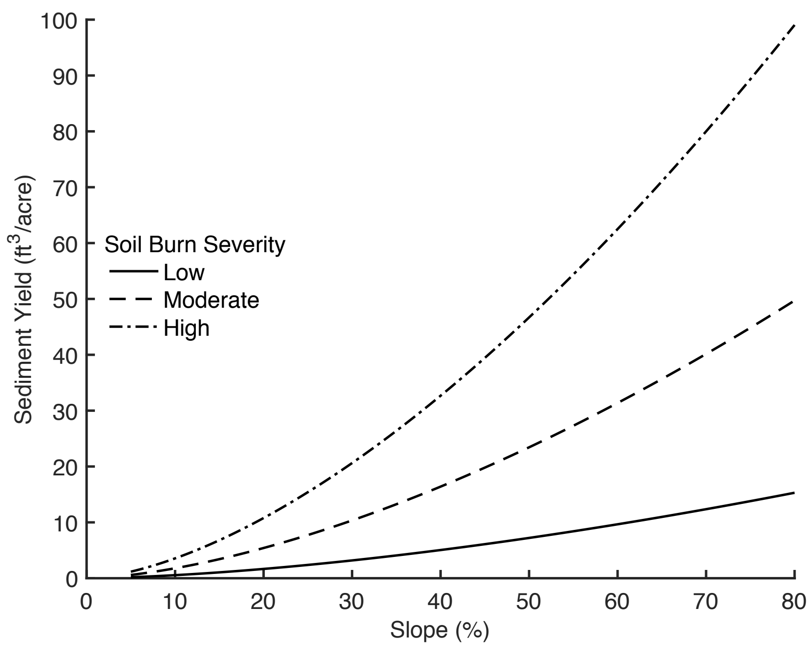
LIDAR-Derived Sediment Yield from 2011 Las Conchas Fire (NM)



Pelletier and Orem, *Earth Surface Processes and Landforms* (2014)

Methods: Sediment Yield Vulnerability

Equation for Sediment Yield



Pelletier and Orem, *Earth Surface Processes and Landforms* (2014)

Methods: Sediment Yield Vulnerability

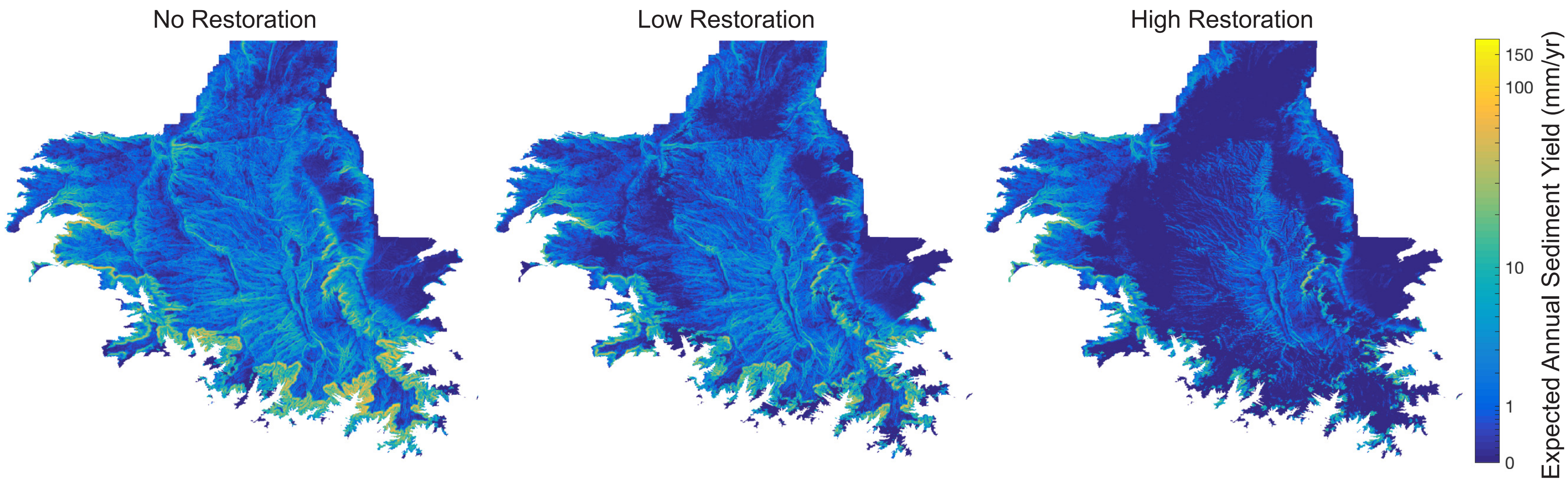
$$\begin{array}{c} \text{Expected Annual} \\ \text{Sediment Yield} \end{array} = \begin{array}{l} \left[\begin{array}{c} \text{Annual Probability of} \\ \text{High Severity Fire} \end{array} \times \begin{array}{c} \text{Calculated Sediment Yield} \\ \text{for High Severity Fire} \end{array} \right] + \ldots \\ \left[\begin{array}{c} \text{Annual Probability of} \\ \text{Moderate Severity Fire} \end{array} \times \begin{array}{c} \text{Calculated Sediment Yield} \\ \text{for Moderate Severity Fire} \end{array} \right] + \ldots \\ \left[\begin{array}{c} \text{Annual Probability of} \\ \text{Low Severity Fire} \end{array} \times \begin{array}{c} \text{Calculated Sediment Yield} \\ \text{for Low Severity Fire} \end{array} \right] \end{array}$$

Relative Measure of Sediment Yield Vulnerability Calculated for Each Cell

Based on LANDIS Simulations

From Equations Developed for the Las Conchas Fire

Results: Sediment Yield Vulnerability



Conclusions

- High-elevation forests are most vulnerable to reductions in water yield due to climate change.
- A high restoration rate is effective in mitigating the effects of climate change in mid-elevation forests.
- Restoration is expected to reduce vulnerability to post-fire sediment yield in mid-elevation forests, and also has positive effects for high- and low-elevations

Acknowledgements

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